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DIGITAL TELEVISION

Service Considerations

and

Allotment Principles

Prepared by

JTCAB Ad Hoc Group on DTV Planning Parameters

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Service Considerations and Allotment Principles

EXECUTIVE SUMMARY

The primary objective in allotment planning for the introduction of Over the Air (OTA) Digital Television (DTV) is to provide a DTV channel for each existing NTSC TV assignment and allotment and to provide a DTV coverage comparable to the existing TV broadcasting service. Service criteria, planning parameters, and allotment principles are based on implementing the ATSC A/53 standard DTV system using the conventional single transmitter configuration.

The document has four sections covering Planning criteria including spectrum considerations, DTV reception conditions, DTV transmissions conditions and Separation distances to meet protection requirements. Each section considers the work of earlier planning studies, the approach by FCC in their proposed rule making and finally the approach and parameters being recommended for the development of the Canadian DTV allotment plan.

A. Planning Criteria

The overall objective in Canadian allotment planning is to provide, in descending order of priority, a DTV allotment for every existing regular and low power NTSC station and also to provide a DTV allotment for every existing unassigned NTSC allotment. The DTV service should be comparable to the existing NTSC service and should replicate the present coverage area to the extent possible. The service or coverage area for NTSC is defined as the area within the radial distance to the protected (i.e. Grade B) contour. For DTV, the service area is defined as the area within the radial distance to the noise plus interference limited contour, i.e. the contour at which the required performance and service availability for the DTV service is satisfied.

Each DTV channel is allotted/assigned based on service replication of the coverage of the existing NTSC allotment or station using the maximum parameters for the class of the existing allotment or station or the present parameters if less. The DTV channel is paired with the NTSC station or allotment and assumed to be located at the same site as the paired NTSC station or allotment. A flex factor of 8 km is included for the location of the DTV transmitter to allow for cases where the DTV service cannot be accommodated at the existing NTSC site.

Protection from interference to both NTSC and DTV services extends to the coverage contours based on their maximum parameters. The planning approach will attempt to minimize interference into both NTSC and DTV equally.

The **service availability** is based on providing coverage in a service area with an availability of **(90,90)** i.e. at 90% of the locations and 90% of the time. This level of availability is considered

necessary due to the sharp failure characteristic of DTV. The implication of this abrupt failure characteristic and required service availability may require further consideration after some long term field experience.

With the spectrum management objective of improved spectrum efficiency in mind, a proposed reduction of the current TV broadcast spectrum is factored into the allotment planning. The Canadian studies includes assessment of the core spectrum requirements for a DTV only plan that meet the Canadian requirements with minimum changes from the interim plan. A major part of the planning work will be to meld the Canadian DTV allotment plan with the proposed US plan taking into account the use of common spectrum near the border area.

B. Receiving Considerations

Near the edge of coverage, the receiver noise figure has a direct effect on the required field strength and hence the resulting required transmitter power. For DTV service in Canada, the figure of 5 dB is used (achieved by the use of a low noise preamplifier installed on the antenna mast to minimize down lead loss effect).

For the final allotment planning in Canada, the following receiving system parameters are used.

Parameter	Low VHF	High VHF	UHF
Frequency MHz	69	195	645
Antenna Gain (dipole) dB	6	8	10
Front-to-Back Ratio dB	6	12	16
Downlead Loss dB	1.05	1.81	3.29
Balun 300/75 Loss dB	0.5	0.5	0.5
Receiver Noise Figure dB	5	5	10
Man-made Noise dB (T_a equiv.)	8.2	1	0
LNA Noise Figure (dB)	5	5	5
LNA Gain (dB)	20	20	20

Key factors that impact on allotment planning are the required carrier-to-Noise (C/N) at the TV receiver ANT IN terminal and the required co-channel Carrier-to-Interference (C/I). The (C/N) in association with the receive antenna gain, noise figure and desired signal quality establishes the receive field strength requirement and the co-channel (C/I) in association with the receive antenna Front-to-Back ratio determines the required co-channel separation distance. In the Digital TV case, noise and co-channel DTV interference are additive as DTV interference behaves similar to noise. Hence there is a minimum C/(N + I) at the receiver input that needs to be met to achieve a specified threshold picture quality level, normally referred to as Threshold Of Visibility (TOV). Once the TOV value has been established then, for planning purposes, it is necessary to partition the threshold C/(N + I) value between noise (C/N) and co-channel DTV interference (C/I). Based on partitioning equally divided between noise and interference, a **C/N = C/I = 19.5 dB** is proposed at the DTV protected contour.

The minimum required field strength for the three TV bands using the parameters proposed for the final Canadian allotment planning is **35 dBμV/m** for the low VHF band, **33 dBμV/m** for the high VHF band and **39 dBμV/m** for the UHF band compared to 47, 56 and 64 dBμV/m respectively for NTSC.

The protection ratios used in Canadian planning are based upon the values resulting from the measurements and tests of the Grand Alliance DTV system except for the co-channel DTV value which is based on the noise partitioning criteria.

C. Transmitting Considerations

The necessary ERP to produce the required field strength for the noise limited contour at a given distance depends on the ERP (transmitter power, antenna gain, transmission line loss) and antenna height above average terrain. A number of tables present the calculated ERP to produce the required field strength for the different classes of stations assuming replacement channels in the three TV bands; low VHF, high VHF and UHF. The ERP's are given for different time and location availabilities.

The power required for a DTV transmitter is specified as average or RMS power in a linear operating mode whereas NTSC power is given in average power during sync peak in a class C operating mode. This places a limit on the maximum power available at the transmitter; typical transmitters are presently capable of delivering a maximum average power of 50-60 kW in a linear mode. For Canadian planning, an ERP of 1000 kW was used as the maximum limit which is realistic and achievable at economic prices.

D. Separation Tables

Separation distances provide an efficient and effective means for managing interference between NTSC stations and DTV allotments and we believe that such an approach can be used to determine the technical acceptability of DTV channel allotments. The separation tables are based on an equal partitioning between noise and interference in the DTV to DTV case and to keep a degree of balance between interference from NTSC to DTV and from DTV to NTSC. The tables give the separation distances required to protect the TV services of the different classes of stations and form the basis for allotting the frequencies to the DTV service areas.

The appendices and glossary provide supplementary information on the method of deriving the required field strength, the considerations of service availability, Conditions for emission masks and adjacent channel co-location, the effects of short spacings and the terms and acronyms used in the text.

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DIGITAL TELEVISION AHG_DTV003K
Service Considerations and Allotment Principles

Introduction

In Canada, the primary objective in allotment planning for the introduction of Advanced/Digital Television (DTV) is to provide a DTV channel for each existing regular and low power NTSC TV assignment and allotment and to provide a DTV coverage comparable to the existing NTSC TV broadcasting coverage. Under this objective, the DTV allotment planning is based on the following service considerations, allotment principles and planning parameters.

These service criteria, planning parameters, and to a certain extent the allotment principles, are based on a number of assumptions that had to be made in view of the several uncertainties associated with the system approach taken. Because of market size and economical reasons, the reality is that Canada will have to adopt the same system standard for terrestrial DTV broadcasting as the United States.

The allotment planning proposed in this document is therefore based on the following assumptions:

- The DTV system used will be based on the ATSC A/53 standard. The coverage performance of the A/53 system will be similar to the predictions derived from the laboratory tests and the limited field tests in Charlotte, N.C. It is the opinion of JTCAB, however, that the A/53 system has not been sufficiently field tested to derive final technical planning parameters;

- Because the A/53 system does not allow the use of on-channel re-transmitter, the allotment planning is based on the use of a single transmitter/ single frequency transmitter coverage configuration. It is assumed that it will be possible to obtain a suitable service availability in the desired coverage area radius using the DTV A/53 system in the VHF/UHF band in a single transmitter/single frequency transmitter coverage configuration.

The impact of these assumptions are that the technical planning criteria such as the location and time service availability, the required ERP and HAAT to cover a certain area may need to be adjusted to the actual performance and use of the system and the consumer type DTV receivers. Furthermore, if the single transmitter/single frequency transmitter coverage configuration is not sufficiently reliable, additional frequencies will be required to improve the DTV coverage and the service reliability.

This document establishes the service criteria, allotment principles and planning parameters required for the development of a DTV allotment plan that will meet this objective.

Section A establishes the planning criteria including the service objectives and addresses spectrum considerations.

Section B establishes the assumptions for the DTV receiver configuration and characteristics for the specification of a required field strength for minimum reception conditions. Also, the principles for partitioning between noise and co-channel DTV interference are developed.

Section C addresses DTV transmitter considerations and establishes the transmit parameters to provide the desired DTV coverage and availability.

Section D identifies the protection ratio requirements between DTV/DTV and DTV/NTSC and determines the separation distances required to meet the protection criteria.

To the extent applicable each section is divided into three sub-sections. These sub-sections provide:

- the approach and parameters used in earlier DTV planning studies (i.e. studies carried out before the parameters of the Grand Alliance DTV system were known);
- the approach and parameters being recommended by the FCC as specified in the 4th, 5th and 6th Notice of Proposed Rule Making (NPRM) and later adopted in the 4th, 5th, and 6th Reports and Orders. Considering the high degree of coordination required between Canadian and US DTV and NTSC allotments near the border, it was considered to be important to identify the approach being used by the FCC and to clearly indicate where differences exist between the two approaches;
- the approach and parameters being recommended for adoption for the development of the Canadian DTV allotment plan and the identification of spectrum requirements to meet the stated objectives.

A. Planning Criteria

A.1 Overall Objective

A.1.1 Canadian Objective

The overall objective in Canadian allotment planning is to provide, in descending order of priority, a DTV allotment for every existing regular and low power NTSC station and also to provide a DTV allotment for every existing unassigned NTSC allotment. This is to be done without significant interference to NTSC stations. Studies have shown that these objectives can only be met if not all unassigned NTSC allotments are protected.

A.1.2 Current FCC Objective

In the FCC's sixth further Notice of Proposed Rule Making (NPRM) and 6th Report and Order regarding DTV allotments, the objective was to provide a DTV allotment for every existing regular power station and also to provide a DTV allotment for vacant NTSC allotments reserved for educational and public TV. Existing low power NTSC TV stations and existing vacant NTSC allotments are excluded from the planning process. Attempts are made to match the DTV coverage to that of the existing NTSC coverage taking into account existing interference constraints.

A.2 Service Criteria

A.2.1 Initial Canadian Approach

The service criteria used in the initial allotment planning exercises done by the JTCAB Frequency Allotment Planning Group is described below.

The DTV service should be comparable to the existing NTSC service and should replicate the present coverage area. The service area for NTSC is defined as the area within the radial distance to the protected (i.e. Grade B) contour. For DTV, the services area is defined as the area within the radial distance to the noise plus interference limited contour, i.e. the contour at which the required performance and service availability (see Appendix 2 on Service Availability) for the DTV service is satisfied. To establish the replication of coverage area of existing NTSC stations, the DTV coverage area and service is based on providing coverage determined by the radial distance to the location of the protected or Grade B contour of the NTSC station. Where the existing station is operating at maximum parameters for the class of NTSC station its parameters and location of the Grade B contour are established and the DTV coverage area and service is based on these values. Where the existing station is operating at less than maximum parameters for the class of NTSC station, its service was defined by assuming coverage, enclosing or exceeding the existing service area, to a distance equal to the radial distance to the Grade B contour for one of the existing defined classes of station (i.e. 25 km for class A, 70 km for class C, 82 km for class VU, etc.). For NTSC stations operating in the UHF band, maximum parameters are known for the defined (A,B,C) classes of stations. For stations operating in the VHF band, maximum parameters are only defined for one class of stations, VL for channels 2 - 6 and VU for channels 7 - 13 with the result that maximum parameters for other classes of service (A,B,C) had to be developed. By assuming service to the radial distance for each class of station with a given EHAAT, the maximum VHF parameters for NTSC operation required to provide coverage to the Grade B contour were determined and are shown in Table A.2.1. Thus, for stations operating with less than maximum parameters, a station class was assigned which provided coverage that equaled or exceeded the existing coverage of the station. These values are the equivalent NTSC parameters to provide service in the VHF bands to the distances of each class. The DTV coverage area and service is based on replicating the coverage of the NTSC station by assuming coverage to the Grade B of one of the classed of stations in Table A.2.1. The

allotment planning and associated interference analysis is based on the maximum parameters for the NTSC station which provide the required service for the different classes of stations (BPR-IV for the UHF band, Table A.2.1 for the VHF band).

Protection for the NTSC service will continue to be the area within the protected or Grade B contour. For the DTV service, the area within the noise and interference limited contour will be the protected service area. Allotments will minimize interference to all services and restrictions due to unavoidable interference will be balanced between services i.e. reductions or changes to parameters of affected services will be distributed between services. Protection from interference will extend throughout the coverage area to the protected contour and will be determined by the protection ratio established for the DTV and NTSC systems. Interference will be evaluated on the basis of F(50,10) propagation statistics.

Table A.2.1
Maximum NTSC VHF Parameters for
Service Replication Coverage of UHF, VU and VL Classes

Band	Class	A	B	C	LP	VU	VL
7-13	ERP(dBk) (kW)	-1.5 0.7	7 5	19 80	-4 0.4	25 325	NA
2-6	ERP(dBk) (kW)	-7 0.2	1 1.2	12 17	-10 0.1	17 50	20 100
2-13	EHAAT(m)	100	150	150	30	150	150
2-13	Grade B Dist (km)	25	45	70	12	82	89

For service availability, planning is based on contour locations determined with the F(50,50) curves with an adjustment for 90% of the time resulting in a service area with an (50,90) availability for location and time. In DTV service with its sharp failure characteristic, this level of availability may result in noticeable DTV service unavailability particularly near the edge of the noise and interference limited contour when compared to analog NTSC reception. See Appendix 2 for more details regarding the characteristics of DTV service availability.

A.2.2 FCC Approach

In the adopted FCC allotment plan, service criteria is more restrictive with DTV channels provided only for existing regular power NTSC stations and for vacant allotments reserved for educational or public TV (i.e.non-commercial allotments). Existing low power TV stations and existing vacant NTSC allotments were not considered (i.e. not provided a DTV allotment nor

protected from DTV allotments). The DTV service and coverage is based on replicating the existing service area of the NTSC station taking into account both terrain and interference effects. The NTSC service area is defined as the lesser of the area within the protected contour or the Grade B contour or the area within the existing interference limited contour. For DTV, the service area is defined as the area within the radial distance to the noise limited contour, i.e. the contour at which the minimum carrier-to-noise (C/N) ratio for the DTV system is satisfied. It should be noted that partitioning between allowable noise and co-channel DTV interference is not considered in the FCC's approach.

Protection for the NTSC service continues to be the area within the protected or Grade B contour. For the DTV service, the area within the noise and interference limited contour is the protected service area. Allotments minimize interference to all services and unavoidable interference is balanced between services. Protection from interference extends throughout the coverage area to the protected contour and is determined by the protection ratio established for the DTV and NTSC systems. Interference is evaluated on the basis of F(50,10) propagation statistics.

For service availability, planning is based on contour locations determined with the F(50,50) curves with an adjustment for 90% of the time resulting in a service area with an (50,90) availability for location and time. In DTV service with its sharp failure characteristic, this level of availability may result in noticeable DTV service unavailability particularly near the edge of the noise limited contour when compared to analog NTSC reception.

A.2.3 Proposed Canadian Approach

A.2.3.1 Criteria for Canadian Approach

Service criteria for the development of the final Canadian DTV allotment plan is based on the same principles used in the initial planing as described in section A.2.1.

A DTV channel will be provided for all existing NTSC TV services, including regular and low power services and for all existing vacant TV allotments, on a priority basis. Regular power services would be accommodated first, followed by low power services and finally vacant allotments. After DTV requirements have been met, vacant NTSC allotments will be assessed to determine whether they can be retained or replaced without impacting the DTV plan.

Each DTV channel will be allotted/assigned based on service replication of the coverage of the existing NTSC allotment or station using the present parameters and/or the maximum parameters for the class of the existing allotment or station. The DTV channel will be paired with the NTSC station or allotment and assumed to be located at the same site as the paired NTSC station or allotment. A flex factor of 8 km is included for the location of the DTV channel to allow for cases where the DTV service cannot be accommodated at the existing NTSC site. To match NTSC service areas, DTV coverage must extend to the Grade B protected contour of the NTSC station it duplicates, i.e. matching the following radial distances:

NTSC Service	Protected Contour Distance
Low VHF	89 km
High VHF	82 km
UHF Class A	25 km
UHF Class B	45 km
UHF Class C	70 km
Low Power	12 km

Protection from interference to both NTSC and DTV services will extend to the coverage contours based on their maximum parameters. Planning will attempt to minimize interference to all services and restrictions due to unavoidable interference will be apportioned equally between services. Evaluation and analysis of interference will be determined using computer methods based on the F(50,50) and F(50,10) propagation curves with adjustments applied to adjust to F(90,90) and F(10,10) when necessary.

The planning is also based on the use of existing sites and co-locating the DTV facilities at the NTSC sites. Co-location and the use of adjacent channels require the establishment of rules governing siting and the use of an emission mask. A study was done by CRC to determine the effects and requirements of co-location, use of adjacent channels and emission masks. (Included in Appendix 3). The results of the study were used to produce the rules for using the emission mask. These rules are as follows:

NTSC/DTV Adjacent Channel Allocation: if adjacent channels are used, they must be co-located.

Rules of using "relaxed-mask":

- NTSC/DTV must be co-sited (exact co-location), for adjacent channel assignment;
- for adjacent channel NTSC/DTV co-siting, DTV MUST be 12 dB (or more) below NTSC.

Rules of using "tight-mask":

- 5-mile (8-km) flex is allowed for NTSC/DTV adjacent channel assignment;
- for co-siting case, DTV and NTSC can transmit at the same power level. (Note: it is preferred that NTSC is allocated to the N+1 channel, instead of N-1 channel.)

When NTSC is switched off: adjacent channel assignments should be avoided as much as possible.

If adjacent channel DTV/DTV is un-avoidable:

- "relaxed-mask" allow co-siting DTV/DTV adjacent channel assignment with a DTV power difference of 14 dB; or
- "relaxed-mask" allow 5-mile flex for DTV/DTV adjacent channel assignment with a DTV power difference of 2 dB;

· "tight-mask" allow co-siting DTV/DTV adjacent channel assignment with an (estimated**) DTV power difference of 17-19 dB; or
· "relaxed-mask" allow 5-mile flux for DTV/DTV adjacent channel assignment with an (estimated**) DTV power difference of 5-7 dB.

(** Note: when the tight-mask is used, the adjacent channel spill-over is far from white-noise. It is difficult to estimate the DTV receiver performance, since different adaptive equalizers might be used, which act differently to non-white noise. There is no ATSC reference receiver. Based on our experience, a 3-5 dB improvement in comparison to relaxed-mask case is achievable.)

Using computer simulations, a study investigated the possibilities of mixing DTV/DTV and DTV/NTSC transmitter classes and the effect it would have on the permissible distance (flex) between the co-located transmitters. The study developed a set of tables giving permissible flex distances for adjacent channel stations of mixed classes. It recommended that mixed transmitters classes should be avoided as much as possible. When absolutely necessary, the flex distances and mixing of classes given in Tables 1 to 6 must be respected. Practically, adjacent stations, whether DTV-DTV or NTSC-DTV, should be in comparable classes. When mixing classes, it is necessary to ensure that it is a valid combination and that the sites chosen respect the flex distances given in Tables 1-6.

Table A.2.3.1: L-VHF : DTV to DTV Separation Distance Between Different Classes (assuming relaxed emission masks are used).

	L-VHF	L-VHF-HV	L-VHF-C	L-VHF-B	L-VHF-A	LP
L-VHF	18km	11 km	0	X	X	X
L-VHF-HV		19 km	7 km	X	X	X
L-VHF-C			20 km	X	X	X
L-VHF-B				18 km	X	X
L-VHF-A					11 km	X
LP						12 km

Table A.2.3.2: H-VHF : DTV to DTV Separation Distance Between Different Classes (assuming relaxed emission masks are used).

	H-VHF-LV	H-VHF	H-VHF-C	H-VHF-B	H-VHF-A	LP
H-VHF-LV	18 km	11 km	0 km	X	X	X
H-VHF		19 km	7 km	X	X	X
H-VHF-C			20 km	X	X	X
H-VHF-B				18 km	X	X
H-VHF-A					11 km	X
LP						12 km

Table A.2.3.3: UHF: DTV to DTV Separation Distance Between Different Classes (assuming relaxed emission masks are used).

	UHF-LV	UHF-HV	UHF-C	UHF-B	UHF-A	LP
UHF-LV	6 km	0 km	X	X	X	X
UHF-HV		7 km	X	X	X	X
UHF-C			10 km	X	X	X
UHF-B				13 km	X	X
UHF-A					9 km	X
LP						4 km

Table A.2.3.4: L-VHF : DTV to NTSC (assuming tight emission mask is used).

	NTSC L-VHF (dB)	Flex Distance (km)
L-VHF	8.69	11
L-VHF-HV	5.46	14
L-VHF-C	0.07	34
L-VHF-B	-10.77	69
L-VHF-A	-22.99	74
LP	-34.19	> 89

Table A.2.3.5: H-VHF : DTV to NTSC (assuming tight emission mask is used).

	NTSC H-VHF (dB)	Flex Distance (km)
H-VHF-LV	10.52	1
H-VHF	7.65	10
H-VHF-C	-0.15	26
H-VHF-B	-9.19	50
H-VHF-A	-20.99	66
LP	-33.45	> 82

Table A.2.3.6 UHF: DTV to NTSC Separation Distance Between Different Classes (assuming tight emission masks are used).

	NTSC UHF-C (km)	NTSC UHF-B (km)	NTSC UHF-A (km)	NTSC LP (km)
UHF-LV	X	X	X	X
UHF-HV	X	X	X	X
UHF-C	8	X	X	X
UHF-B		12	X	X
UHF-A			8	X
LP				3

The service availability will be based on providing coverage in a service area with a specified availability of (50,90) or (90,90) and consideration of both is given in the planning and development of the criteria. The availability of (50,90) i.e. at 50% of the locations and 90% of the time, as noted in section A.2.1, may need to be improved due to the sharp failure characteristic of DTV. The implication of this will require further consideration. Service availability is discussed in Appendix 2 in more detail.

A.2.3.2Criteria for Interim Plan

The development of the interim plan uses a specific set of criteria and band assignment priorities. The selection of a DTV channel for each regular power NTSC station uses a service availability of (90,90) for channels 2-59 and (50,90)for channels 60-69. Distance separations between stations or channels were developed using a (10,10) model for DTV to DTV interference and a (50,10) model for DTV to NTSC interference. The separation tables are given in section D.3 and section D.4. Channel requests not initially satisfied use short spacing to fulfill all remaining regular station requirements, still with (90,90) availability. Short spacings between DTV and NTSC are permitted first and between DTV and DTV last. The selection of a DTV channel for NTSC allotments uses the same criteria as for regular power stations. For low power NTSC stations, DTV allotments are made using (90,90) availability to the extent possible. Short spacings are used to meet all requirements on a similar basis as for regular stations and allotments.

Based on the spectrum considerations given in section A.3, the following band assignment priorities are used for the allotment of DTV channels in the interim plan.

BAND	PRIORITY
Ch. 7-13	1st
Ch. 14-59	2nd
Ch. 2-6	3rd
Ch. 60-69	4th

Short spacings are allowed between DTV and NTSC are allowed before putting allotments in the channel band of 60-69. In the channel band from 2 to 59, short spacings between DTV and DTV channels are used only as a last option.

A.3 Spectrum Considerations

A.3.1 Canadian Approach

An objective in spectrum management is to improve the efficiency of spectrum usage. Present NTSC usage of the spectrum for TV Broadcasting involves the channels and spectrum shown in Figure 1. Considerations in the allotment planning includes a proposed reduction of the band, which involves using only Ch 7-13 and Ch 14-51 shown shaded in Figure 2 as the core spectrum for DTV broadcasting. For an interim period during the transition from NTSC to DTV, use of all channels will continue. DTV channels operating outside the core block would move to the core spectrum when NTSC services are discontinued and channels become available. The strategy for planning will be to develop a Canadian plan with consideration of all Canadian requirements and to meld this plan with the adopted US plan as presented in the FCC's sixth Report and Order.

Canadian planning studies will include an assessment of how many channels are required for a DTV-only plan[1]:

a) if channel changes from the interim DTV/NTSC plan are minimized;

b) with no channel constraints from the DTV/NTSC plan.

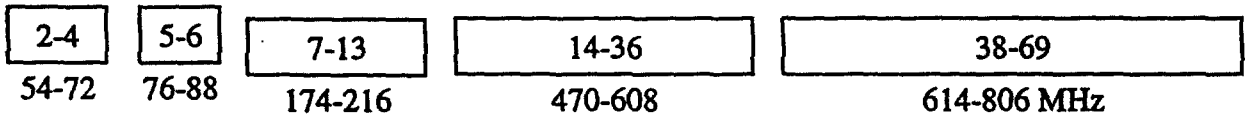

Figure 1 Current TV Broadcast Spectrum

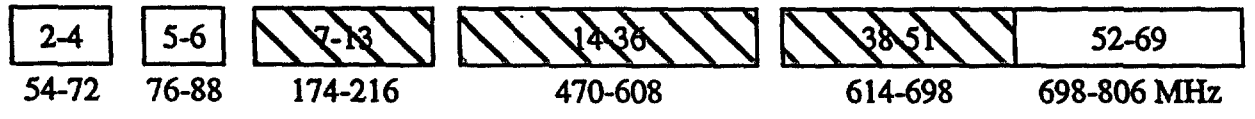

Figure 2 Proposed TV Broadcast Spectrum

Canadian studies to date have looked at several variations of the above, where the final DTV only plan would use:

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[1]Further studies will be required in sharing with the land mobile systems adjacent to TV channels 14 and 69.

- all currently available channels
- the current UHF channels only
- the shaded channels in Figure 2
- VHF channels 7-13 and UHF channels 14-36 and 38-55
- VHF channels 7-13 and UHF channels 14-36 and 38-59

Following completion and adoption of this paper, a draft Canadian allotment plan will be developed, giving priority to the shaded channels in Figure 2 for DTV allotments and protecting the draft US plan to the extent possible. Shortened separations between DTV allotments on the shaded channels will be avoided. Next a straw man final plan for DTV only will be developed. In the DTV only plan, it will be assumed that all DTV allotments on the shaded channels will be maintained and that all stations whose DTV allotment is outside those channels, but whose NTSC channel is within, will use the latter for DTV. If all remaining DTV requirements cannot be met on these channels, different options will have to be explored, such as expanding the band or reallotting some channels.

A.3.2 FCC Approach

As described in section A.1.2 on the service criteria, the FCC have only considered regular power stations and only those allotments which are designated non-commercial. They are considering a spectrum option, the one shown in Figure 2, where all future digital TV service would be located in a core spectrum region of the existing VHF and UHF TV broadcast spectrum, namely the spectrum at TV channels 7 to 51 from 174-216 MHz and from 470-698 MHz. Under this plan, they have attempted to accommodate all existing broadcasters and designated non-commercial allotments with a DTV channel inside the core spectrum. Because of spectrum availability, existing NTSC services and interference considerations, some DTV channels are assigned outside the core area during the transitional phase. These DTV channels outside the core area would move into the core spectrum as channels become available from the closing of NTSC operations and release of channels.

This option, if successful, would permit the eventual recovery of 138 MHz of spectrum. Their plan, which minimizes the number of digital TV allotments in channels 60-69, calls for possible early recovery of 60 MHz of spectrum, i.e. channels 60-69, because of the limited use of these channels by full service analog and digital broadcasters. They propose to make channels 60-69 available to other services on a non-interference basis shortly after reaching a decision, and later open access to channels 52-59. However, at this time it is not clear when and how much of this spectrum will become available for other services.

In the 6th Report and Order, the adopted plan includes the above core spectrum approach but also

includes another possible core spectrum option which uses Ch. 2-46 in place of Ch. 7-51.

B. Receiving Considerations

B.1 Receiving System Model

B.1.1 General Receiver Configuration

A model of a typical receiving installation located near the edge of the service area is shown in Figure 3 consisting of an externally mounted antenna, a interconnecting downlead cable and an ATV receiver. The amplifier symbol shown in the ATV receiver represents the input

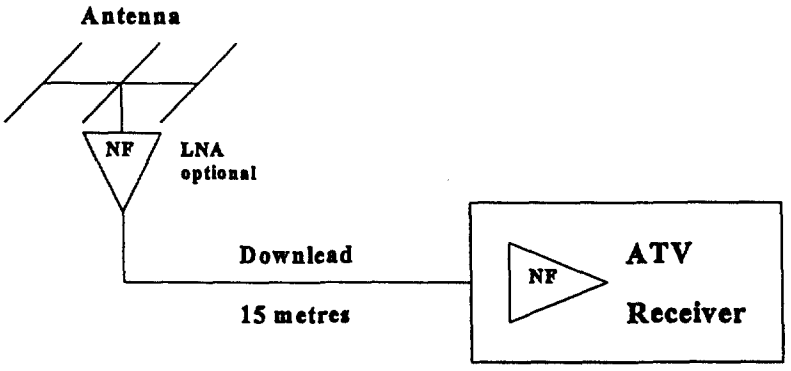

Figure 3. Receiving System Model

amplification circuitry which also determines the receiver noise figure. In the UHF TV band, it may be necessary to add an additional LNA mounted at the antenna to achieve a low noise figure equal to the noise figure for the VHF TV bands. The receiver configuration model described applies to locations near the edge of the coverage area (i.e. weak signal conditions).

B.1.2 Preliminary Receiving Parameters (Canadian)

The table below gives the parameters of the receiving system that were assumed during the preliminary allotment planning investigations carried out within JTCAB.

The choice of antenna gain was based on a reasonable assumption for gain for the VHF band

representative of a three element Yagi type antenna. For the UHF band, the figure of 10 dB was chosen as representative of a standard UHF antenna without a high degree of complexity. The receiving antenna front-to-back ratio is based on values given in ITU-R Recommendation 419-2 which are representative of performance readily available with current antennas.

Parameter	Low VHF	High VHF	UHF
Frequency MHz	69	195	645
Antenna Gain (dipole) dB	6	8	10
Front-to-Back Ratio dB	6	12	16
Downlead Loss dB	2.5	3.3	4.9
Receiver Noise Figure dB	6	6	6
Man-made Noise dB (T_a equiv.)	8.2[2]	1	0

B.1.3 FCC Receiving Parameters (US)

The table below gives the parameters of the receiving system proposed for use in the US. The values were obtained from the FCC's sixth notice and are based on the numbers from the ATV test data.

Parameter	Low VHF	High VHF	UHF
Frequency MHz	69	194	615
Antenna Gain (dipole) dB	4	6	10
Front-to-Back Ratio dB	10	12	14
Downlead Loss dB	1	2	4
Receiver Noise Figure dB*	5	5	10
Man-made Noise dB*	4	1	0

* These values were changed in FCC's sixth Report and Order, see B.3.2.

B.1.4 Proposed Receiving Parameters (Canadian)

The receiver noise figure has a direct effect on the required field strength to provide coverage and

[2]Assumed noise for a rural environment using information from ITU-R Report 258-5.

the resulting required transmitter power. In the UHF band for service in Canada, an appropriate figure may be 5 dB (achieved by the use of a low noise preamplifier installed at the antenna output on the mast).

For the final allotment planning in Canada, the following receiving system parameters are proposed.

Parameter	Low VHF	High VHF	UHF
Frequency MHz	69	195	645
Antenna Gain (dipole) dB	6	8	10
Front-to-Back Ratio dB	6	12	16
Downlead Loss dB	1.05	1.81	3.29
Balun 300/75 Loss dB	0.5	0.5	0.5
Receiver Noise Figure dB	5	5	10
Man-made Noise dB (T_a equiv.)	8.2	1	0
LNA Noise Figure (dB)	5	5	5
LNA Gain (dB)	20	20	20

B.2 Receiving System Parameters

In the analog TV case, the two parameters that are key factors that impact on allotment planning are the required carrier-to-Noise (C/N) at the TV receiver ANT IN terminal and the required co-channel Carrier-to-Interference (C/I). The (C/N) in association with the receive antenna gain, noise figure and desired signal quality establishes the receive field strength requirement and the co-channel (C/I) in association with the receive antenna Front-to-Back ratio determines the required co-channel separation distance.

In the Digital TV case, noise and co-channel DTV interference are additive as DTV interference behaves similar to noise. Hence there is a minimum C/(N + I) at the receiver input that needs to be met to achieve a specified threshold picture quality level, normally referred to as Threshold Of Visibility (TOV). Once the TOV value has been established then, for planning purposes, it is necessary to partition the threshold C/(N + I) value between noise (C/N) and co-channel DTV interference (C/I).

B.2.1 Minimum C/(N + I)

The minimum value of C/(N + I) for the 8 VSB Grand Alliance system has been measured in laboratory and field tests. Laboratory test results on the GA system report a value of 15.28 dB corresponding to TOV[3]. However this value represents the minimum C/N for TOV without additional impairments resulting from multipath and interference that would be expected to be present in the field. Based on the review of lab tests reported in the document referenced in the footnote, an additional headroom of 1.2 to 3.6 dB is required for typical multipath distortion. Assuming the minimum recommended headroom of 1.2 dB results in a minimum C/(N + I) of 16.5 dB at TOV.

B.2.2 Partitioning Between Noise & DTV Interference

Based on the above discussion and considering that the impact of DTV interference is noise like then it remains to establish an optimum partitioning between noise and co-channel interference at the DTV protected contour. Aspects to consider in this partitioning are:

- a higher threshold C/N, for a given receiver figure-of-merit (G/T) and coverage distance, translates into higher DTV transmit parameter values (HAAT and/or EIRP). Hence the value adopted for C/N must be within feasible limits for DTV transmit parameters corresponding to the most demanding case (i.e. DTV UHF-LV).

- On the other hand, a higher value of threshold C/N results in improving the balance in the spacings required for DTV interfering into NTSC (DTV/NTSC) and NTSC interfering into DTV (NTSC/DTV);

Based on these considerations and on further consideration of NTSC interfering into DTV as discussed in the next section, it is proposed that the partitioning be equally divided between noise and interference. **This results in a C/N = C/I = 19.5 dB at the DTV protected contour.**

B.2.3 NTSC Interference into DTV

The required C/I for NTSC interfering into DTV depends on whether a comb filter is used in the DTV receiver. Based on lab tests summarized in the document referenced in the footnote, with the comb filter in a C/I of 7.2 dB (NTSC/DTV) is required corresponding to a C/N of 19.4 dB. Without the comb filter the C/I required is 19.9 dB corresponding to a C/N of 16 dB which implies that the comb filter degrades the C/N by approximately 3.9 dB compared to the

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[3]Document 11-3/CAN 2, 21 October 1996 "***DTV C/N Requirement for the 8-VSB Transmission System in a Noise Dominated Channel (MHz)*** " Submitted by CRC to TG 11-3 Meetings, Sydney Australia, November 1996

theoretical degradation of 3 dB. The comb filter will only be required during the transition phase when both DTV and NTSC are in operation. After the phase out of NTSC service, there will be a 3.9 dB improvement in the DTV carrier-to-noise ratio which means either an improvement in service availability or a reduction in transmitter power is possible.

Thus, assuming that the co-channel interference will either be DTV or NTSC and not both in the same instance, and that the comb filter will be used in areas where performance is constrained by NTSC interference and switched out in those areas where performance is constrained by noise and/or DTV interference then a value of co-channel **C/I of 7.2 dB for NTSC into DTV will be appropriate.** Note also that this arrangement fits nicely with the assumption on Interference and Noise partitioning made in B.2.2 (i.e. threshold C/N = 19.5 dB).

B.3 Required Minimum Field Strength

The field strength required to provide ATV service for a given C/N ratio can be determined by:

$$C/N(dB) = \Phi(dBW/m^2) - G_i(1m^2) + G_A/T_e - K - B_{rf}$$

$$E_{RX}(dB\mu V/m) = \Phi(dBW/m^2) + 145.8(dB)$$
$$= 145.8 + C/N + 10\log k + 10\log B + G_i(1m^2) - G_A + T_e$$

E_{RX}	required field strength at the receive system antenna
Φ	power flux density at the receive system antenna
C/N	carrier to noise ratio
k	Boltzmann's constant
B	system bandwidth
$G_i(1m^2)$	gain of 1 metre squared
G_A/T_e	G/T of the receive system
G_A	gain of the receive system (isotropic) (see Appendix 1 for derivation)
Te	effective noise temperature (see Appendix 1 for derivation)

This method for deriving the field strength is given in detail in Appendix 1.

B.3.1 Preliminary Planning Parameters (Cdn)

The minimum required field strength for the three TV bands using the parameters assumed for the preliminary Canadian planning is given in Table B.3.1 below.

Table B.3.1

Preliminary Canadian Planning Parameters

Planning Parameter	Low VHF	High VHF	UHF
Frequency (MHz)	69	195	645
C/N (dB)	16.1	16.1	16.1
k (dB)	-228.6	-228.6	-228.6
B (dB) (6 MHz)	67.78	67.78	67.78
$G_i(1m^2)$ (dB)	-1.77	7.25	17.64
$G_{dipole\ (dB)}$	6	8	10
$G_{isotropic\ (dB)}$	8.15	10.15	12.15
Line Loss (dB) α (numeric)	2.5 0.56	3.3 0.47	4.9 0.32
Receiver Noise Figure (dB)	6	6	6
T_{rx}	864.5	864.5	864.5
T_{line}	126.9	154.4	196.2
αTa	5584.4	262.4	0
T_e	6575.8	1281.3	1060.7
$10\log(T_e)$	38.18	31.08	30.26
$G_{A\ (dB)}$	5.65	6.85	7.25
E_{read}	32	33	42

B.3.2 FCC Planning Parameters (US)

In the US, the method to determine required field strength is based on thermal noise at the